U.S. ENVIRONMENTAL PROTECTION AGENCY REGION 5

Union Station Air Monitoring Survey

Summary of PM2.5 data

9/28/2015

CONTENTS

SUMMARY

The U.S. Environmental Protection Agency collected 14 days of $PM_{2.5}$ data over a three week period (June 15 to July 2, 2015) on the north and south platforms at Chicago's Union Station to characterize $PM_{2.5}$ concentrations during the weekday commuter rush hour and non-rush hour periods. EPA also collected background (street-level) $PM_{2.5}$ data during the field monitoring period. EPA found short-term localized peaks of $PM_{2.5}$ near locomotives on the Union Station platforms, and hourly and sampling session average concentrations that were consistently elevated over background levels.

INTRODUCTION

$PM_{2.5}$ is particulate matter that is 2.5 micrometers (µm) in diameter and smaller. These fine particles contain microscopic solids or liquid droplets that are so small that they can get deep into the lungs and cause serious health problems. These health problems include aggravated asthma, decreased lung function and increased respiratory symptoms, such as irritation of the airways, coughing or difficulty breathing.

At Union Station, EPA measured ambient air $PM_{2.5}$ concentrations on the platforms for 14 days, collecting minute and hourly averages using TSI SidePak™ photometers. The overall goal of this survey was to characterize ambient air concentrations at Union Station platforms to determine: 1) short-term (minute) $PM_{2.5}$ concentrations in order to characterize peak maximum concentrations and the frequency of peaks over multiple hours (rush and non-rush hours) as well as different days (to account for any meteorological effects); and 2) hourly and sampling session averages to understand overall air quality on Union Station platforms compared with background (street-level) concentrations.

METHODS

EPA collected data each weekday as one-minute averages using three TSI SidePak™ photometers. Each day's sampling (Figure 1) consisted of one to two background concentrations generally for 10-15 minutes during the walk to/from 77 West Jackson Boulevard to Union Station and two to four platform tests per day (sampling sessions) that were each at least 45 minutes long (Table S1 and Figure S1). Over the 14 days EPA researchers collected (n = 64) platform tests at the Union Station platforms and background concentrations (n=35). For the final four days of collection, background concentrations were collected for approximately an hour around the exterior of Union Station to represent street-level concentrations for a comparable time frame to the collection at the underground platforms.

The TSI SidePak™ Personal Aerosol Monitor Model AM510 is a portable, lightweight, battery-operated laser photometer that measures real-time airborne particulate matter mass concentrations. It uses light scattering technology to measure the mass aerosol concentrations from a continuous stream of air that is drawn in through the sampler and into the sensing chamber with the photometer.[1]

Traditional air monitors are stationary and are expensive to purchase and operate. Sensors, such as the TSI SidePak™, are useful in collecting data to capture spatial or temporal trends that may not be easily

[1] (TSI. (2012). *SIDEPAK™ AM510 PERSONAL AEROSOL MONITOR THEORY OF OPERATION*. Retrieved from http://www.tsi.com/uploadedFiles/_Site_Root/Products/Literature/Application_Notes/ITI-085.pdf)

monitored using traditional stationary monitors. By using sensors rather than stationary monitors, EPA researchers moved around platforms and collected data closer to locomotives. However, as compared with data collected using traditional stationary monitors, concentrations collected by sensors are generally less accurate and precise, and may be affected by factors such as temperature, humidity and particle composition[2] .

QUALITY ASSURANCE/QUALITY CONTROL

SidePak™ photometers used at Union Station were certified by the manufacturer in October of 2014. Quality control procedures included flow-rate calibrations, pre- and post-sampling flow rate verifications, pre-sampling zero calibrations and post-sampling zero tests (considered trip blanks). National Institute of Standards and Technology (NIST) traceable flow standards were used for quality control flow-rate calibrations and verifications.

Throughout the survey, an EPA researcher wore and operated three SidePak™ photometers simultaneously. Operating the photometers simultaneously allowed EPA to account for variability between instruments, given that these instruments are not as accurate as traditional filter-based or continuous methods. All days had three instruments running, except afternoon hours of day four because one photometer was temporarily undergoing maintenance. Limits for variability between instruments were set as 30 percent absolute relative percent difference or 15 $\mu g \cdot m^{-3}$, whichever is larger, for hourly averages. No hourly average exceeded this criteria. [Background concentrations were collected for most runs (n=35) unless weather prohibited, and ranged from 12-101 $\mu g \cdot m^{-3}$ (Table S2). Trip blanks, or zero blanks, collected at the end of every sampling period for that day ranged from 0-10 $\mu g \cdot m^{-3}$.] Data was not corrected for background or blanks.

RESULTS AND DISCUSSION

Minute data

EPA plotted data collected on the platforms as one-minute averages to show short-term trends that the photometers observed throughout the survey (Figure 1). Results showed concentration peaks occurring one to seven times per hour, and observed for one to 10 minutes, and ranging from 200-3500 $\mu g \cdot m^{-3}$. These peaks occurred when the sensors were relatively close to a locomotive, and peaks sharply dissipated as researchers walked away from the locomotives while transecting the platform (Figures 1(a) and 1(b)). EPA researchers occasionally observed elevated concentrations across the entire platform while several locomotives were moving (Figure 1(c)). Similar peaks were not observed in background

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[2] 1) Hall, E.S.; Kaushik, S.M.; Vanderpool, R.W.; Duvall, R.M.; Beaver, M.R.; Long, R.W.; Solomon, P.A. "Integrating Sensor Monitoring Technology into the Current Air Pollution Regulatory Support Paradigm: Practical Considerations". *American Journal of Environmental Engineering*. 2014, 4(6): 147-154. 2) Jiang, R.T.; Acevedo-Bolton, V.; Cheng,K.C.; Klepeis, N.E.; Ott ,W.R.; Hildemann, L.M. "Determination of response of real-time SidePak AM510 monitor to secondhand smoke, other common indoor aerosols, and outdoor aerosol". *Journal of Environmental Monitoring.* 2011 Jun;13(6): 1695-702. 3) Sánchez, J. A.; Van Tongeren, M.; Galea, K.S.; Steinsvåg, K.; MacCalman, L.; Cherrie JW. "Comparison of the SidePak personal monitor with the Aerosol Particle Sizer (APS)". *Journal of Environmental Monitoring.* 2011 Jun;13(6):1841-6.

concentration measurements, which had relatively low variability, even when monitoring next to major streets (Figure 1(d)).

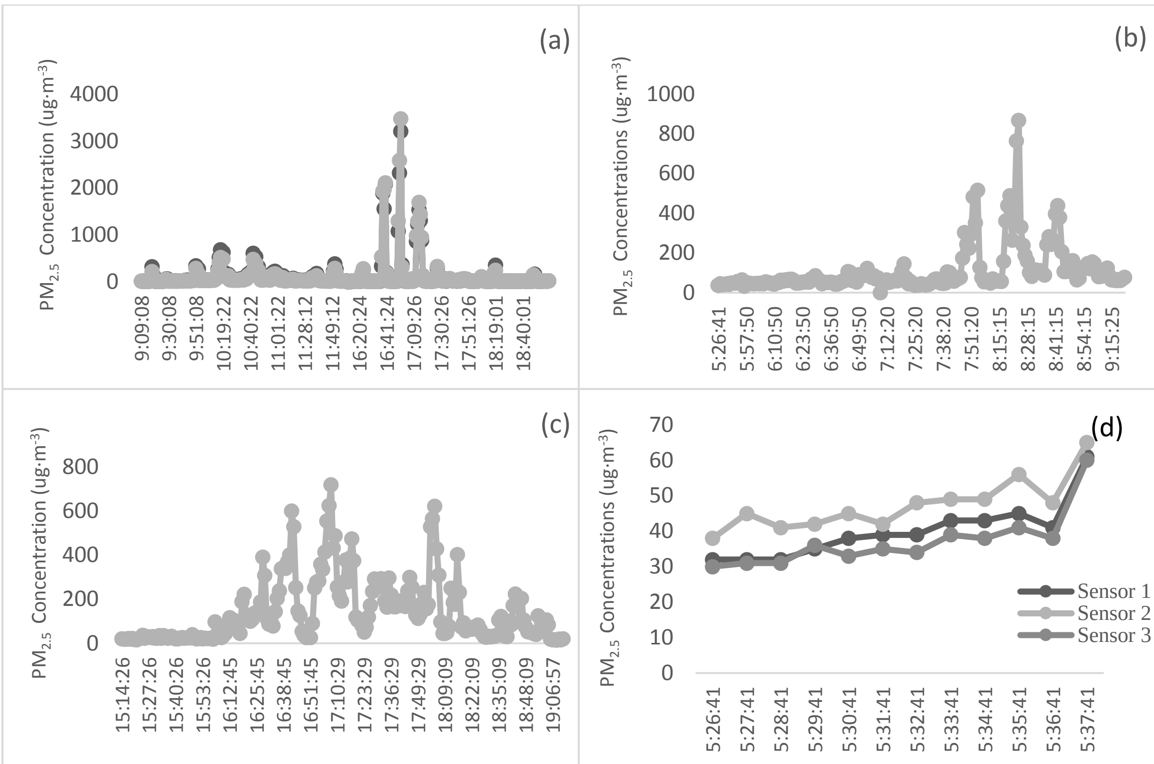

Figure 1. Time series plots for both platforms on different days: (a) June 18 south platform; (b) June 15 north platform; (c) July 2 south platform; and (d) June 15 background.

Hourly averages

EPA calculated hourly test averages from the one-minute data, then averaged the hourly averages for the three instruments for each test (Figure 2). Hourly averages ranged from 33 – 673 $\mu g \cdot m^{-3}$. Figure 3 shows averages plotted for each sample hour during the day, where the hour was averaged across different sample days (i.e. 06:00 was averaged for days 1, 2, 8, 9, 11, 12; 09:00 averaged over days 3, 4, 6, 7). Higher average concentrations occurred during rush hours in the morning and evening, with highest average concentrations at 07:00 (228 $\mu g \cdot m^{-3}$) and 17:00 (299 $\mu g \cdot m^{-3}$).

Concentrations measured on underground platforms at Union Station were consistently higher than background concentrations, which averaged 12-101 $\mu g \cdot m^{-3}$ (Table S2). Platform concentrations, when compared with background from the same day, were 23-96 percent higher than the background.

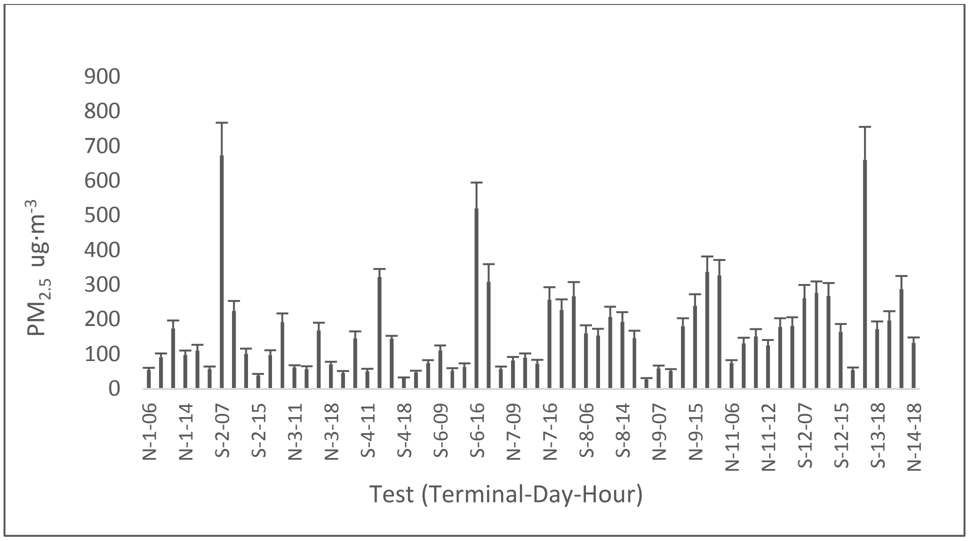

Figure 2. Hourly average $PM_{2.5}$ concentrations plotted for each sample day's tests (n=64), where each average is calculated from all three instruments' recorded hourly average, and standard deviation represents the variability among instruments.

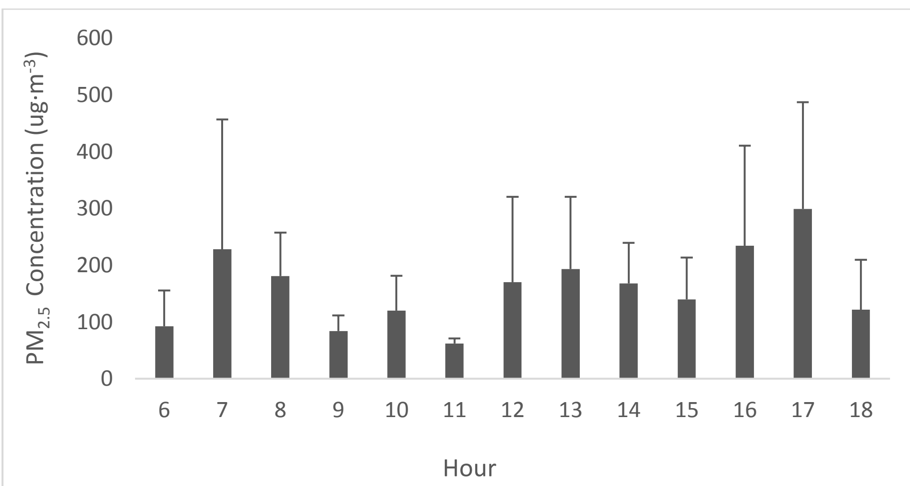

Figure 3. Averages for each hour measured over the entire sampling period, with the standard deviation representing variability between different days but the same sampling hour.

Sampling session averages

Sampling session averages, the average of all platform tests for a given day, ranged from 61 – 333 μg ·m^{-3} (Figure 4), with an overall average of 166 μg ·m^{-3} for the entire sampling session. These averages only account for daytime and weekday measurements; overnight and weekend averages may affect the average concentration over a 24-hour period. Comparison between platform measurements shows the south platform has higher concentrations than the north platform, with the overall averages of 129 μg ·m^{-3} for the north platform (n=32) and 203 μg ·m^{-3} for the south platform (n=32). The maximum hourly average on the north platform was 287 μg ·m^{-3}, with 47 percent of hourly averages above 100 μg ·m^{-3}, while the south platform had a maximum hourly average of 687 μg ·m^{-3} and 69 percent of hourly averages were above 100 μg m^{-3} and 9 percent of hourly averages above 500 μg ·m^{-3}.

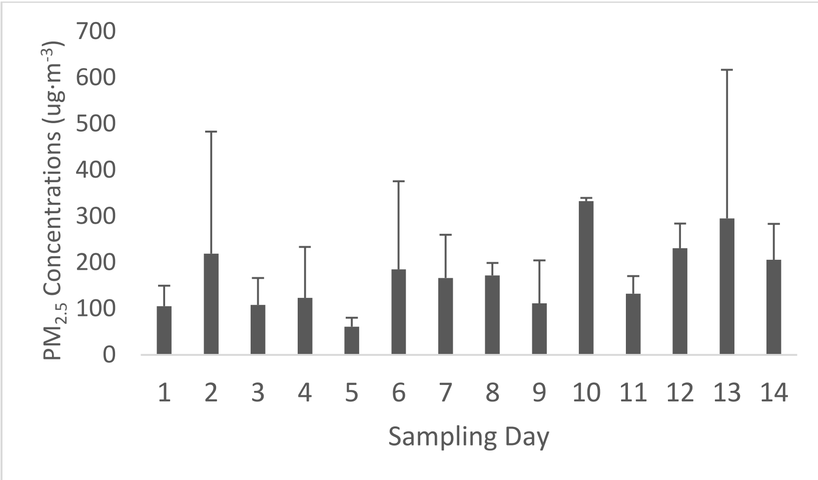

Figure 4. Sampling session averages ranged from 61 – 333 μg ·m^{-3}, with an overall average of 166 μg ·m^{-3} over the entire sampling session, where the standard deviation represents variability of the different platforms and time frames measured during the sampling day

CONCLUSION

The monitoring data demonstrate that locomotives and insufficient ventilation in Union Station are contributing to elevated levels of $PM_{2.5}$. Specifically, these 14 days of collected data demonstrate that:

- Short-term localized peaks in $PM_{2.5}$ levels occur when the monitors are closest to the locomotives idling in the station.
- Concentrations measured on platforms at Union Station are consistently higher than background concentrations measured at street level.
- Higher hourly average concentrations were seen during rush hour periods than non-rush hour periods.
- Levels of $PM_{2.5}$ are generally higher on the south platform than the north platform.

The $PM_{2.5}$ measurements from this survey can be used to understand relationships and patterns in spatial and temporal concentrations of $PM_{2.5}$ at Union Station.

SUPPLEMENTAL INFORMATION

	6:00:00 AM	7:00:00 AM	8:00:00 AM	9:00:00 AM	10:00:00 AM	11:00:00 AM	12:00:00 PM	1:00:00 PM	2:00:00 PM	3:00:00 PM	4:00:00 PM	5:00:00 PM	6:00:00 PM
Day 1	North Platform								North Platform				
Day 2	South Platform								South Platform				
Day 3				North Platform							North Platform		
Day 4				South Platform							South Platform		
Day 5							North Platform				North Platform		
Day 6				South Platform							South Platform		
Day 7				North Platform							North Platform		
Day 8	South Platform								South Platform				
Day 9	North Platform								North Platform				
Day 10							South Platform				South Platform		
Day 11	North Platform								North Platform				
Day 12	South Platform								South Platform				
Day 13							North Platform				South Platform		
Day 14							South Platform				North Platform		
Day 15				North Platform							South Platform		

Figure S1. Collection schedule used during sampling

Table S1. Hourly averages throughout the survey with QA/QC criteria and meta data.

	Details					Mean, $ug{\cdot}m^{-3}$	Test Hourly Average, mg/m^3		
	Terminal	**Day**	**Hour**	**Platform**	**Field Log ID**		**SN_08**	**SN_11**	**SN_13**
N-1-06	**North**	**1**	**06**	**13-15**	06152015_North_0600_0900	54	0.061	0.049	0.052
N-1-07	**North**	**1**	**07**	**5-7**	06152015_North_0600_0900	91	0.103	0.082	0.087
N-1-08	**North**	**1**	**08**	**9-11**	06152015_North_0600_0900	174	0.200	0.159	0.164
N-1-14	**North**	**1**	**14**	**5-7**	06152015_North_1400_1600	97	0.112	0.086	0.094
N-1-15	**North**	**1**	**15**	**13-15**	06152015_North_1400_1600	110	0.129	0.098	0.104
S-2-06	**South**	**2**	**06**	**26-28**	06162015_South_0600_0900	57	0.065	0.051	0.054
S-2-07	**South**	**2**	**07**	**2-4**	06162015_South_0600_0900	673	0.777	0.593	0.649
S-2-08	**South**	**2**	**08**	**14-16**	06162015_South_0600_0900	225	0.256	0.199	0.219
S-2-14	**South**	**2**	**14**	**10-12**	06162015_South_1400_1600	101	0.118	0.09	0.096
S-2-15	**South**	**2**	**15**	**2-4**	06162015_South_1400_1600	38	0.044	0.035	0.036
N-3-09	**North**	**3**	**09**	**1-3**	06172015_North_0900_1200	98	0.113	0.087	0.093

N-3-10	**North**	**3**	**10**	**13-15**	06172015_North_0900_1200	192	0.221	0.172	0.183
N-3-11	**North**	**3**	**11**	**9-11**	06172015_North_0900_1200	61	0.069	0.055	0.059
N-3-16	**North**	**3**	**16**	**13-15**	06172015_North_1600_1900	57	0.066	0.05	0.055
N-3-17	**North**	**3**	**17**	**1-3**	06172015_North_1600_1900	168	0.193	0.148	0.163
N-3-18	**North**	**3**	**18**	**5-7**	06172015_North_1600_1900	71	0.079	0.064	0.069
S-4-09	**South**	**4**	**09**	**2-4**	06182015_South_0900_1200	46	0.052	0.041	0.045
S-4-10	**South**	**4**	**10**	**14-16**	06182015_South_0900_1200	146	0.168	0.13	0.139
S-4-11	**South**	**4**	**11**	**10-12**	06182015_South_0900_1200	50	0.059	0.044	0.048
S-4-16	**South**	**4**	**16**	**14-16**	06182015_South_1600_1900	323	N/A	0.306	0.339
S-4-17	**South**	**4**	**17**	**2-4**	06182015_South_1600_1900	144	N/A	0.138	0.150
S-4-18	**South**	**4**	**18**	**6-8**	06182015_South_1600_1900	33	N/A	0.032	0.033
N-5-12	**North**	**5**	**12**	**1-3**	06192015_North_1200_1400	47	0.053	0.043	0.046
N-5-13	**North**	**5**	**13**	**13-15**	06192015_North_1200_1400	74	0.084	0.067	0.072
S-6-09	**South**	**6**	**09**	**26-28**	06222015_South_0900_1200	110	0.127	0.098	0.105
S-6-10	**South**	**6**	**10**	**2-4**	06222015_South_0900_1200	52	0.060	0.046	0.050
S-6-11	**South**	**6**	**11**	**14-16**	06222015_South_0900_1200	64	0.074	0.056	0.061
S-6-16	**South**	**6**	**16**	**2-4**	06222015_South_1600_1900	520	0.603	0.459	0.497
S-6-17	**South**	**6**	**17**	**14-16**	06222015_South_1600_1900	309	0.366	0.273	0.288

S-6-18	**South**	**6**	**18**	**10-12**	06222015_South_1600_1900	57	0.065	0.051	0.055
N-7-09	**North**	**7**	**09**	**13-15**	06232015_North_0900_1200	82	0.093	0.073	0.080
N-7-10	**North**	**7**	**10**	**1-3**	06232015_North_0900_1200	90	0.103	0.080	0.086
N-7-11	**North**	**7**	**11**	**9-11**	06232015_North_0900_1200	72	0.085	0.064	0.068
N-7-16	**North**	**7**	**16**	**1-3**	06232015_North_1600_1900	257	0.296	0.224	0.251
N-7-17	**North**	**7**	**17**	**13-15**	06232015_North_1600_1900	227	0.261	0.202	0.219
N-7-18	**North**	**7**	**18**	**5-7**	06232015_North_1600_1900	267	0.312	0.234	0.256
S-8-06	**South**	**8**	**06**	**2-4**	06242015_South_0600_0900	160	0.185	0.141	0.155
S-8-07	**South**	**8**	**07**	**26-28**	06242015_South_0600_0900	154	0.175	0.137	0.15
S-8-08	**South**	**8**	**08**	**14-16**	06242015_South_0600_0900	207	0.240	0.182	0.199
S-8-14	**South**	**8**	**14**	**10-12**	06242015_South_1400_1600	193	0.225	0.172	0.182
S-8-15	**South**	**8**	**15**	**2-4**	06242015_South_1400_1600	146	0.170	0.128	0.14
N-9-06	**North**	**9**	**06**	**1-3**	06252015_North_0600_0900	27	0.031	0.025	0.026
N-9-07	**North**	**9**	**07**	**9-11**	06252015_North_0600_0900	59	0.068	0.053	0.056
N-9-08	**North**	**9**	**08**	**17-19**	06252015_North_0600_0900	51	0.058	0.046	0.049
N-9-14	**North**	**9**	**14**	**13-15**	06252015_North_1400_1600	180	0.206	0.162	0.173
N-9-15	**North**	**9**	**15**	**1-3**	06252015_North_1400_1600	239	0.277	0.213	0.227
S-10-12	**South**	**10**	**12**	**14-16**	06262015_South_1200_1400	338	0.384	0.298	0.331

S-10-13	**South**	**10**	**13**	**2-4**	06262015_South_1200_1400	327	0.377	0.293	0.312
N-11-06	**North**	**11**	**06**	**17-19**	06292015_North_0600_0900	74	0.084	0.067	0.072
N-11-07	**North**	**11**	**07**	**1-3**	06292015_North_0600_0900	131	0.149	0.117	0.127
N-11-08	**North**	**11**	**08**	**13-15**	06292015_North_0600_0900	151	0.174	0.134	0.145
N-11-12	**North**	**11**	**12**	**13-15**	06292015_North_1200_1400	125	0.143	0.113	0.119
N-11-13	**North**	**11**	**13**	**1-3**	06292015_North_1200_1400	179	0.206	0.16	0.171
S-12-06	**South**	**12**	**06**	**26-28**	06302015_South_0600_0900	181	0.209	0.161	0.174
S-12-07	**South**	**12**	**07**	**2-4**	06302015_South_0600_0900	262	0.302	0.229	0.255
S-12-08	**South**	**12**	**08**	**10-12**	06302015_South_0600_0900	277	0.312	0.248	0.27
S-12-14	**South**	**12**	**14**	**2-4**	06302015_South_1200_1400	268	0.31	0.24	0.255
S-12-15	**South**	**12**	**15**	**14-16**	06302015_South_1200_1400	165	0.189	0.146	0.16
S-13-16	**South**	**13**	**16**	**14-16**	07012015_South_1600_1900	54	0.062	0.048	0.052
S-13-17	**South**	**13**	**17**	**2-4**	07012015_South_1600_1900	660	0.768	0.591	0.622
S-13-18	**South**	**13**	**18**	**10-12**	07012015_South_1600_1900	172	0.197	0.154	0.164
N-14-16	**North**	**14**	**16**	13-15	07022015_North_1600_1900	197	0.226	0.175	0.191
N-14-17	**North**	**14**	**17**	**1-3**	07022015_North_1600_1900	287	0.329	0.254	0.279
N-14-18	**North**	**14**	**18**	**5-7**	07022015_North_1600_1900	132	0.149	0.118	0.129

Table S2. Background averages throughout the survey with QA/QC criteria and meta data

Test	Field Log ID	Test Average, mg/m^3			Mean, $ug{\cdot}m^{-3}$
		SN_08	SN_11	SN_13	
B-1-06	**06152015_North_0600_0900**	0.047	0.037	0.04	41
B-1-09	**06152015_North_0600_0900**	0.079	0.063	0.065	69
B-1-14	**06152015_North_1400_1600**	0.033	0.021	0.027	27
B-1-16	**06152015_North_1400_1600**	0.078	0.061	0.064	68
B-2-06	06162015_South_0600_0900	0.029	0.023	0.025	26
B-2-09	06162015_South_0600_0900	0.03	0.023	0.025	26
B-2-14	06162015_South_1400_1600	0.015	0.014	0.013	14
B-2-16	06162015_South_1400_1600	0.012	0.011	0.014	12
B-3-09	06172015_North_0900_1200	0.03	0.02	0.025	25
B-3-18	06172015_North_1600_1900	0.041	0.032	0.035	36
B-5-11	06192015_North_1200_1400	0.02	0.015	0.019	18
B-5-14	06192015_North_1200_1400	0.028	0.022	0.024	25
B-6-8	06222015_South_0900_1200	0.035	0.027	0.028	30
B-7-8	06232015_North_0900_1200	0.015	0.012	0.013	13

B-7-12	06232015_North_0900_1200	0.021	0.016	0.017	18
B-7-16	06232015_North_1600_1900	0.017	0.012	0.013	14
B-7-19	06232015_North_1600_1900	0.016	0.012	0.016	15
B-8-5	06242015_South_0600_0900	0.019	0.014	0.017	17
B-8-9	06242015_South_0600_0900	0.047	0.034	0.038	40
B-8-14	06242015_South_1400_1600	0.036	0.026	0.03	31
B-8-16	06242015_South_1400_1600	0.032	0.025	0.028	28
B-9-13	06252015_North_1400_1600	0.107	0.089	0.094	97
B-9-16	06252015_North_1400_1600	0.098	0.078	0.083	86
B-10-11	06262015_South_1200_1400	0.092	0.073	0.077	81
B-11-6	06292015_North_0600_0900	0.057	0.05	0.053	53
B-11-11	06292015_North_1200_1400	0.053	0.046	0.048	49
B-11-14	06292015_North_1200_1400	0.072	0.057	0.059	63
B-12-5	06302015_South_0600_0900	0.059	0.047	0.051	52
B-12- 9	06302015_South_0600_0900	0.103	0.081	0.087	90
B-12-11	06302015_South_1200_1400	0.115	0.091	0.097	101
B-12-2	06302015_South_1200_1400	0.111	0.088	0.093	97
B-13-15	07012015_South_1600_1900	0.03	0.022	0.023	25

B-13-19	07012015_South_1600_1900	0.02	0.015	0.016	17
B-14 -15	07022015_North_1600_1900	0.03	0.025	0.026	27
B-14 -19	07022015_North_1600_1900	0.022	0.018	0.02	20

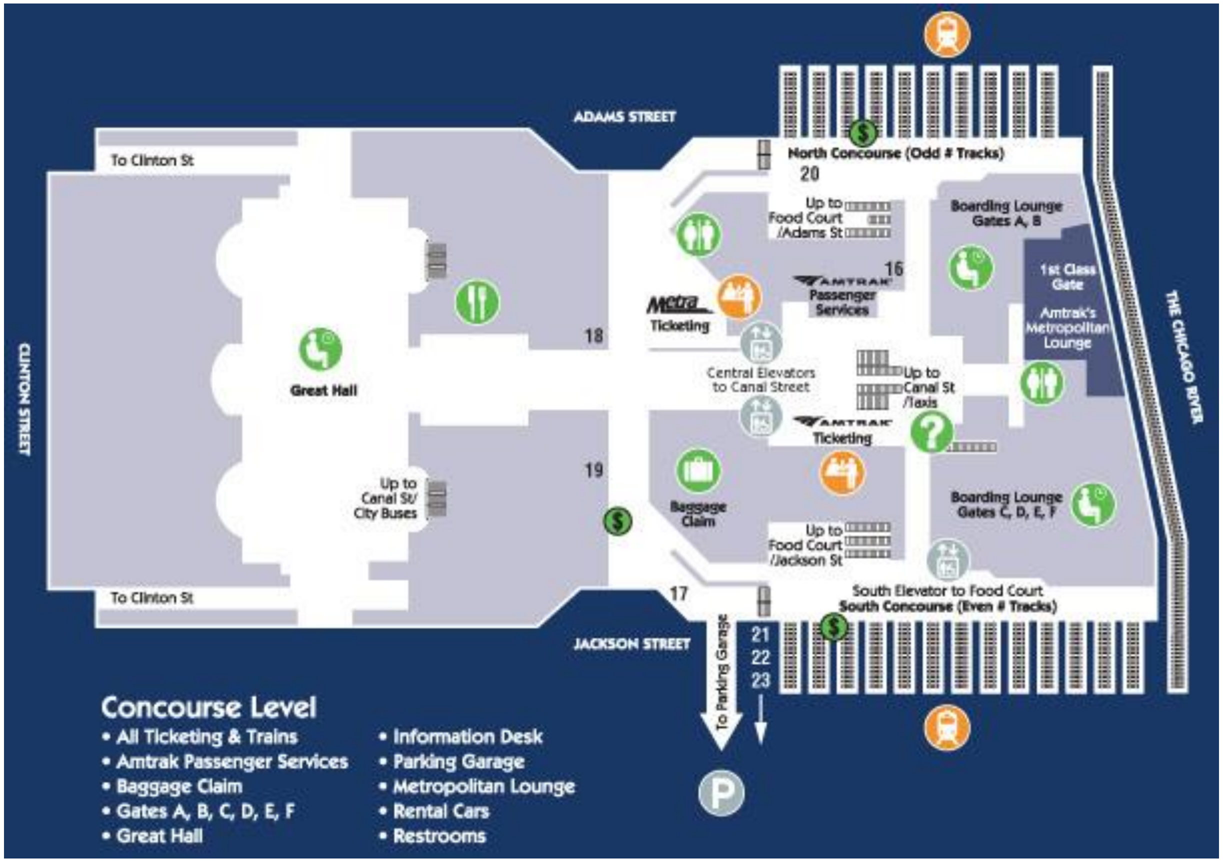

Figure S2. Union Station map with platform locations where monitoring occurred (see orange train icons).